

Two dimensional echocardiography and the tricuspid valve

Leaflet definition and prolapse

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SUMMARY The tricuspid valve was studied in 143 subjects using two dimensional echocardiography. The groups studied were 40 normal subjects, 31 patients with mitral valve prolapse, 22 with clinically probable tricuspid valve prolapse, 20 with congestive cardiac failure, and 30 with miscellaneous cardiac conditions but no features of right heart disease. Using multiple views it was possible to record all three leaflets in 74.8% of cases and anterior and septal leaflets in 95%. Prolapse of the tricuspid valve was recognised in 13 patients: six (19.5%) of the group with mitral valve prolapse and seven (6%) of the remaining patients. Prolapse of all three leaflets was shown in one patient, anterior and septal prolapse in six patients, anterior and posterior in three patients, septal leaflet prolapse alone in two patients, and anterior alone in one patient.

Two dimensional echocardiography allows definition of individual tricuspid leaflets and prolapse of any or all leaflets can be diagnosed. Tricuspid valve prolapse is commonly associated with prolapse of mitral valve leaflets but isolated cases are recognised.

Although Tajik *et al.* in 1978¹ described how all three tricuspid leaflets may be shown by two dimensional echocardiography, most descriptions refer to the anterior and septal leaflets only.²⁻⁴ In this study we describe the ability of two dimensional echocardiography to show three tricuspid leaflets and to show prolapse affecting individual leaflets.

Subjects and methods

The 143 subjects were selected from patients referred to the non-invasive laboratory for investigation. They were divided into five groups. Group 1 consisted of 40 subjects with minimal or no heart disease who served as normal controls. There were 14 male and 26 female subjects, with a mean age of 25.85 years, range 11 to 66 years. Group 2 comprised 31 patients with mitral valve prolapse (15 male, 16 female, mean age 51.7 years, range 14 to 81 years). Group three consisted of 20 patients with congestive cardiac failure including five with cor pulmonale (12 men, 8 women, mean age 66.8 years, range 52 to 85 years). Group 4 comprised 22 patients, nine with definite clinical features of tricuspid regurgitation and 13 with probable tricuspid regurgitation (nine men, 13 women, mean age 54.2

years, range 17 to 79 years). Group 5 consisted of 30 patients (16 male, 14 female patients, mean age 44.8 years, range 8 to 85 years) with miscellaneous cardiac conditions, including chronic rheumatic heart disease, ischaemic heart disease, lone atrial fibrillation, and cardiomyopathy. None of these patients had clinical features of significant right heart disease and tricuspid regurgitation was not suspected.

Echocardiograms were recorded using a Smith-Kline Ekosector I mechanical sector scanner or a Hewlett Packard phased array ultrasound imaging system, model 77020A. Transducers giving 30° and 80° images were available on the Ekosector I, but the 30° transducer gave better definition of leaflet movement, and the images were recorded on a Sanyo videotape recorder. 2.5 MHz and 3.5 MHz transducers were used on the phased array system and the images recorded on a Sony Betamax videorecorder. In both cases images were viewed in slow motion and frame by frame for analysis, and still frame photographs were obtained with a Polaroid camera.

Conventional techniques were used to record M-mode echocardiograms, phonocardiograms, and jugular venous and carotid pulses. Hard copy photographic records were obtained on a Cambridge fibreoptic 12 channel physiological recorder.

Anterior and posterior tricuspid leaflets were

viewed using a long axis view of the right ventricular inflow tract from the left parasternal area (Fig 1). Clockwise rotation of the transducer gave views of both inflow tracts which provided images of the anterior and septal leaflets; this was designated the "short axis" view for ease of description (Fig 2). The anterior and septal leaflets were also viewed in the apical four chamber and subxiphoid views (Fig 3 and 4). Standard criteria^{5,6} were used to diagnose prolapse of the mitral valve, and tricuspid valve prolapse was diagnosed in a similar manner when two dimensional recordings showed that one or more tricuspid leaflets moved superiorly in systole so that they extended beyond a line connecting the basal attachments of the leaflets. Frame by frame analysis was used to define the presence and degree of prolapse.

Results

DEFINITION OF INDIVIDUAL TRICUSPID LEAFLETS

In three patients, the tricuspid valve was not seen on the echocardiogram. All three leaflets were recorded

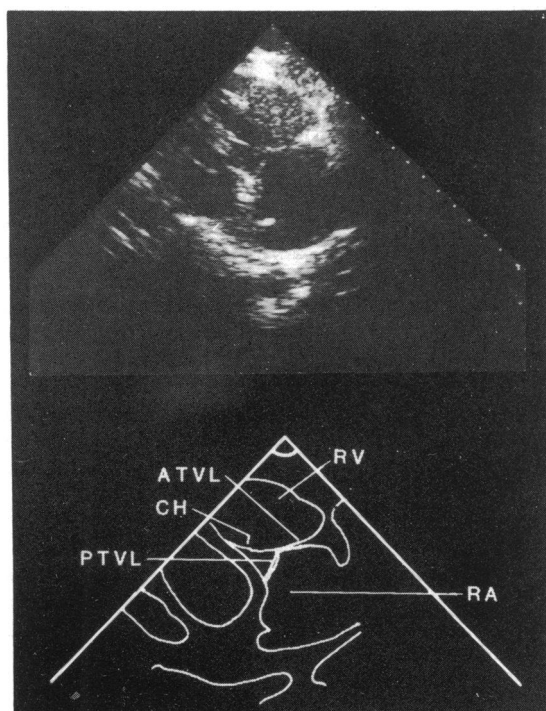


Fig. 1 Two dimensional echocardiogram showing the long axis view of the tricuspid valve in a normal heart. In this view the anterior and posterior leaflets are visible. ATVL, PTVL, anterior and posterior tricuspid valve leaflets; RA, RV, right atrium and ventricle; CH, chordae.

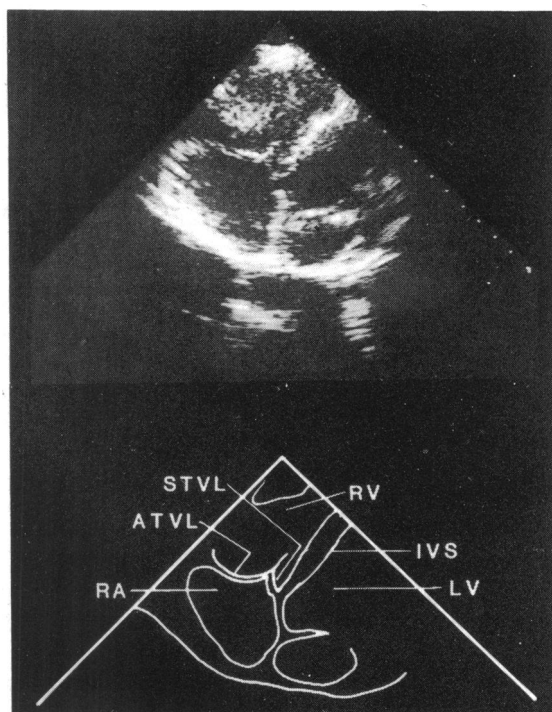


Fig. 2 In this short axis view from the left parasternal border in a normal subject, the anterior and septal tricuspid valve leaflets can be seen. ATVL, STVL, anterior and septal tricuspid valve leaflets; IVS, interventricular septum; RA, RV, right atrium and ventricle; LV, left ventricle.

in 107/143 (74.8%) of subjects. Anterior and septal leaflets were seen in 136/143 (95%) cases. Details of which leaflets were recorded are shown in Table 1. When only one leaflet was shown on the long axis parasternal view of the right ventricular inflow tract it was usually the anterior; in the short axis view the septal leaflet was recorded more often than the anterior; with the apical four chamber view it was the septal leaflet and with the subxiphoid view it was the anterior leaflet usually. Subxiphoid views were inferior to the precordial views in defining the leaflets. The anterior leaflet was best seen on the parasternal view of the right ventricular inflow tract and the septal leaflet was best seen on the parasternal view of both inflow tracts or the apical four chamber view.

DEFINITION OF TRICUSPID VALVE PROLAPSE

Prolapse of the tricuspid valve was found in 13 patients. There were six cases (19.5%) in group 2 (patients with mitral valve prolapse) and seven (6%) of the remaining patients. Prolapse of three leaflets was recognised in one patient; of both anterior and septal leaflets in six patients (Fig. 5); of both anterior and

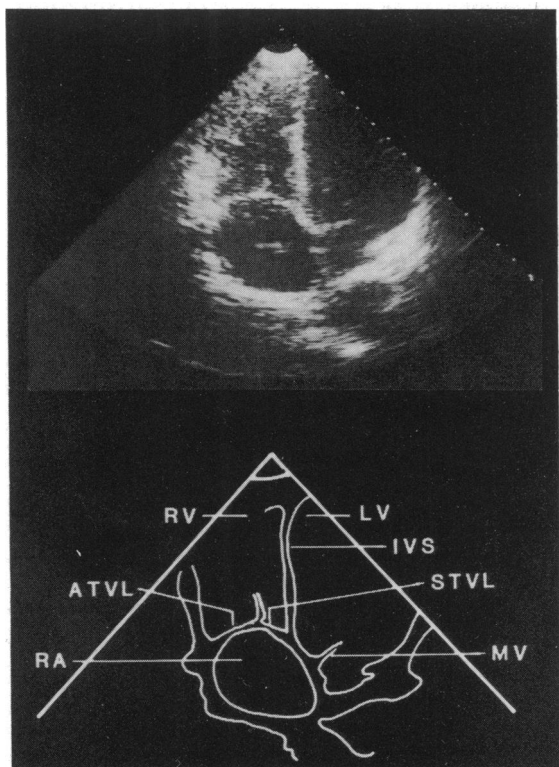


Fig. 3 The normal apical four chamber view, showing the relations of the anterior and septal tricuspid valve leaflets. MV, mitral valve. See Fig. 1 and 2 for abbreviations.

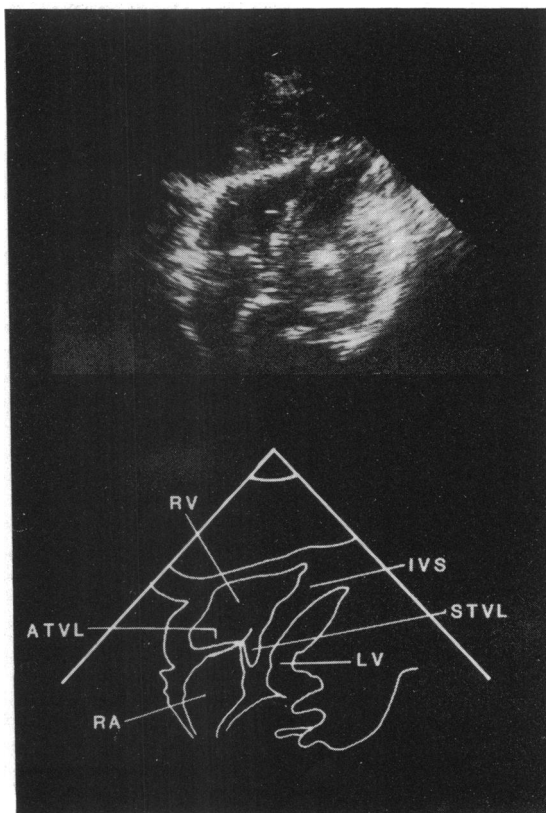


Fig. 4 The subxiphoid view of the tricuspid valve in a normal subject. As in the four chamber and short axis views, only the anterior and septal leaflets can be seen. See Fig. 1 and 2 for abbreviations.

Table 1 Shows which leaflets are recorded from different views: figures show patients in whom no leaflets (0), one leaflet (A) or (P) or (S), and two leaflets (A+S) or (A+P) could be recorded

Group (no. of patients)	Long axis				Short axis				Four chamber				Subxiphoid			
	0	A	P	A+P	0	A	S	A+S	0	A	S	A+S	0	A	S	A+S
1 Normal (40)	2	4	0	34	3	0	9	28	5	0	10	25	19	10	1	10
2 MVP (31)	3	2	0	26	7	0	3	21	4	0	3	24	17	2	0	12
3 CCF+Cor P (20)	3	6	0	11	3	1	3	13	3	2	4	11	7	2	0	11
4 Definite TR (22)	1	3	0	18	2	1	3	16	4	0	2	16	5	2	0	15
5 Probable TR (30)	7	2	0	21	5	2	8	15	6	0	2	22	10	7	0	13
Totals	16	17	0	110	20	4	26	95	22	2	21	98	58	23	1	61

A, anterior; P, posterior; S, septal; MVP, mitral valve prolapse; CCF, congestive cardiac failure; Cor P, cor pulmonale; TR, tricuspid regurgitation.

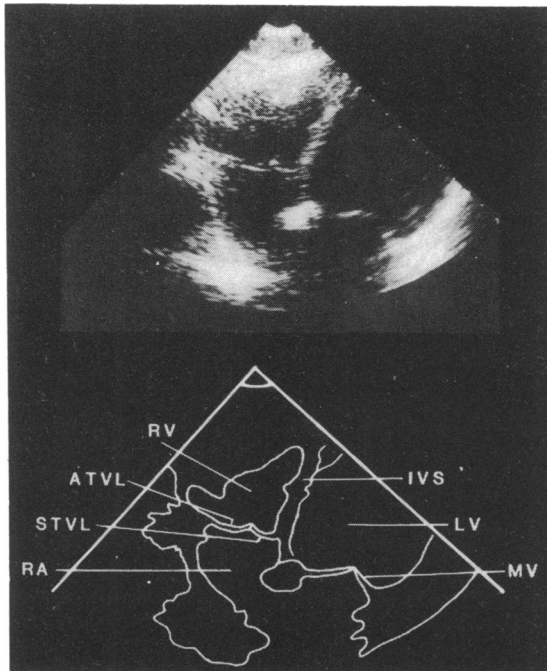


Fig. 5 The subxiphoid view shows prolapse of both anterior and septal leaflets beyond the tricuspid annulus. See Fig. 1 and 2 for abbreviations.

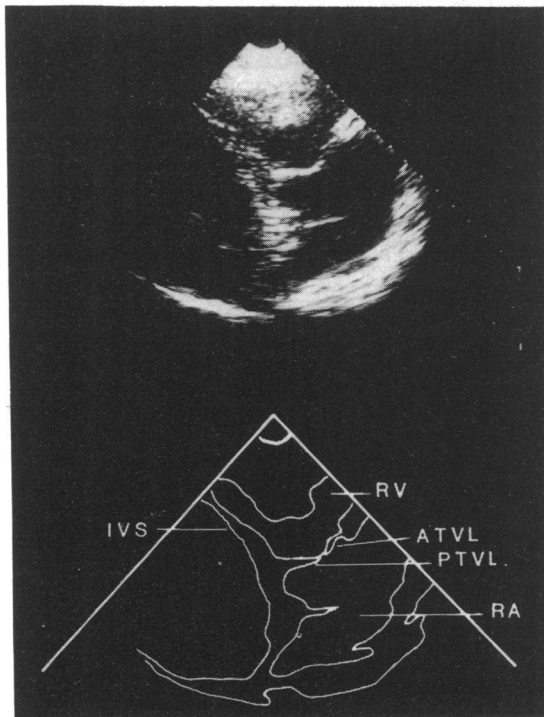


Fig. 6 Long axis view in a patient with prolapse of the anterior and posterior tricuspid valve leaflets. See Fig. 1 and 2 for abbreviations.

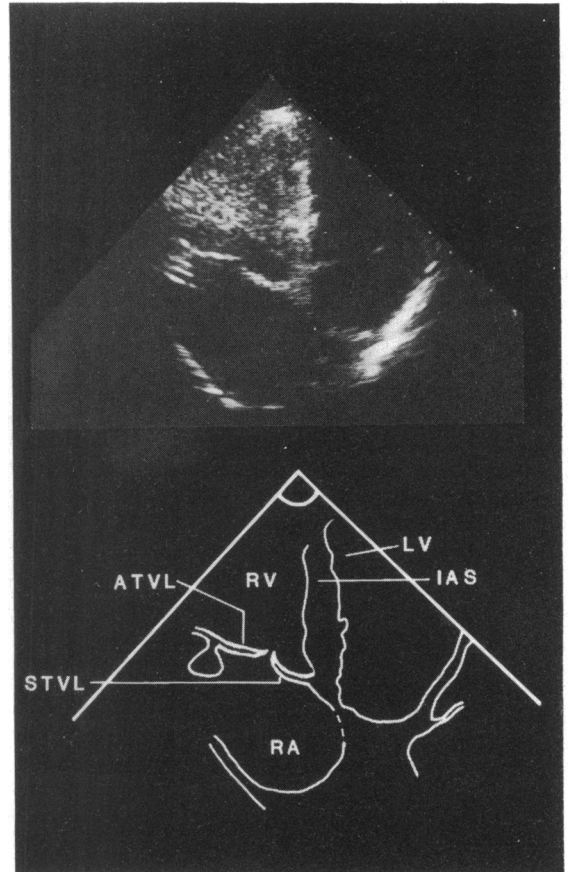


Fig. 7 The four chamber apical view in which the septal leaflet prolapses beyond the level of the tricuspid annulus into the right atrium. The anterior leaflet becomes horizontal. See Fig. 1 and 2 for abbreviations.

posterior leaflets in three patients (Fig. 6); and two patients had prolapse of the septal leaflet alone (Fig. 7). One of these patients was shown to have failure of systolic apposition of the leaflets and was presumed to have a flail leaflet. The remaining patient showed anterior leaflet prolapse alone. Details of the cases and the views which showed the prolapsing leaflets are shown in Table 2.

Discussion

The normal tricuspid valve comprises anterior, posterior, and septal leaflets.^{7,8} The septal cusp is small with its base inserted obliquely across the membranous interventricular septum. The anterior cusp is the largest and is semicircular or quadrangular. The posterior cusp is usually semicircular, scalloped, and intermediate in length between the other two leaflets.

It has been shown that it is possible to record the

Table 2 Details of patients with tricuspid valve prolapse

Group (no. of patients)	Leaflets visible				Prolapse seen (view)	Leaflets prolapsing
	LA	SA	4Ch	Subx		
1 Normal	—	—	—	—	—	—
2 MVP (6)	AP	AS	AS	AS	4Ch+Subx	A+S
	AP	AS	AS	AS	SA+4Ch	A+S
	AP	AS	AS	—	4Ch	A+S
	AP	AS	AS	—	LA+SA+4Ch	A+S
	AP	AS	AS	—	LA	A+P
	AP	AS	AS	A	LA	A+P
3 CCF (0)+Cor P (1)	A	S	S	AS	Subx	A+S
4	AP	AS	AS	AS	SA	A+S
TR definite (2)	AP	AS	—	A	SA+LA	A+P
TR probable (1)	A	S	AS	AS	4Ch+Subx	A
5	—	AS	—	AS	SA	S
Miscellaneous (3)	—	S	AS	AS	Subx	S
	AP	AS	AS	A	LA+SA	A+P+S

LA, long axis; SA, short axis; 4Ch, apical four chamber; Subx, Subxiphoid; A, anterior; P, posterior; S, septal; MVP, mitral valve prolapse; CCF, congestive cardiac failure; Cor P, cor pulmonale; TR, tricuspid regurgitation.

three leaflets on two dimensional echocardiography.^{1,9} Anterior and septal leaflets can be seen on parasternal views of both inflow tracts and on four chamber views from the apex or subxiphoid positions. In our study, the anterior leaflet is less frequently demonstrated than the septal on the precordial views, whereas the subxiphoid approach usually shows the anterior leaflet, and the septal is less commonly seen. Long axis parasternal views of the right ventricular inflow tract show posterior and anterior leaflets. When there is difficulty showing both these leaflets, the posterior is the one not seen. Using the combination of views, all three tricuspid leaflets are shown in 74.8% of our patients, and the anterior and septal leaflets are almost invariably recorded (95%).

Features of tricuspid valve prolapse on two dimensional echocardiography have been described but only two leaflets are discussed. Though Mardelli *et al.*³ and Ogawa *et al.*⁴ describe the use of "right ventricular inflow" views, their illustrations show that they are using the parasternal view of both right and left inflow tracts which allows definition of anterior and septal leaflets but not the posterior leaflet. Werner and associates² describe septal and "mural" leaflets in two cases without further qualification. From our studies it is apparent that prolapse of any or all the tricuspid leaflets may be studied if a combination of views is used. The tricuspid ring may be represented by a line joining the basal attachments of leaflets in each view. Prolapse is diagnosed if one or more leaflets extend beyond this line in systole. Determination of prolapse of tricuspid leaflets is more difficult than the demonstration of mitral valve prolapse. The exact insertion of the basal attachment of the leaflets may be difficult to see and, therefore, the tricuspid ring is not easy to define. In addition, the leaflets of the tricuspid valve are less clearly seen than those of the mitral valve

because the images are less well defined. The oblique insertion of the septal leaflet and its attachment to the septal wall by short chordae has led to the suggestion that it is the one most prone to incompetence.⁷ We have shown that prolapse can affect any or all leaflets if appropriate views are studied, but since the posterior leaflet is shown only on the right ventricular inflow images, this view must be sought with particular care.

Prevalence studies using pathological or angiographic evidence suggest that 21 to 52% of patients with mitral valve prolapse have associated tricuspid valve prolapse.¹⁰ Using M-mode echocardiography, tricuspid valve prolapse was found in 3 to 21% of patients with mitral valve prolapse.^{2,11} Werner *et al.*² could find no cases of isolated tricuspid valve prolapse in 500 routine echocardiograms though after the study they reported three patients with prolapsed tricuspid valve, one after a right ventricular wound, one with vegetations on the valve, and one in association with a large pericardial effusion. Single cases of tricuspid valve prolapse diagnosed by M-mode echocardiography have been described^{12,13} and two similar cases were added by Karayannis *et al.*¹⁴ A further study reported 12 patients with tricuspid valve prolapse, eight with associated mitral valve prolapse.¹⁵ Because of the difficulty of recording other than the anterior leaflet with the M-mode technique, two studies used two dimensional echocardiography. Mardelli *et al.*³ reported 64 cases of mitral prolapse, 31 (48%) of which showed associated tricuspid valve prolapse, and Ogawa *et al.*⁴ found tricuspid valve prolapse in 20/50 (40%) patients with mitral valve prolapse. We found a lower prevalence of tricuspid valve prolapse associated with mitral prolapse (19.5%) even though three leaflets have been assessed in most patients. That this is a true difference from the other series is suggested

by the number of isolated cases of tricuspid prolapse which we have recognised.

We conclude that two dimensional echocardiography is an appropriate technique for the demonstration of tricuspid valve prolapse. Using multiple views it is possible to record anterior and septal leaflets in most subjects. The posterior leaflet is seen only on the long axis parasternal view and every effort must be made to obtain this view. Prolapse of the tricuspid valve is commonly associated with mitral valve prolapse, but isolated cases occur.

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